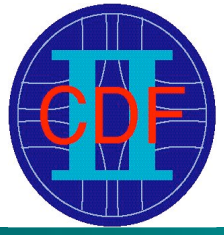


CDF ISL Cooling Update

Peter Wilson

All Experimenters Meeting

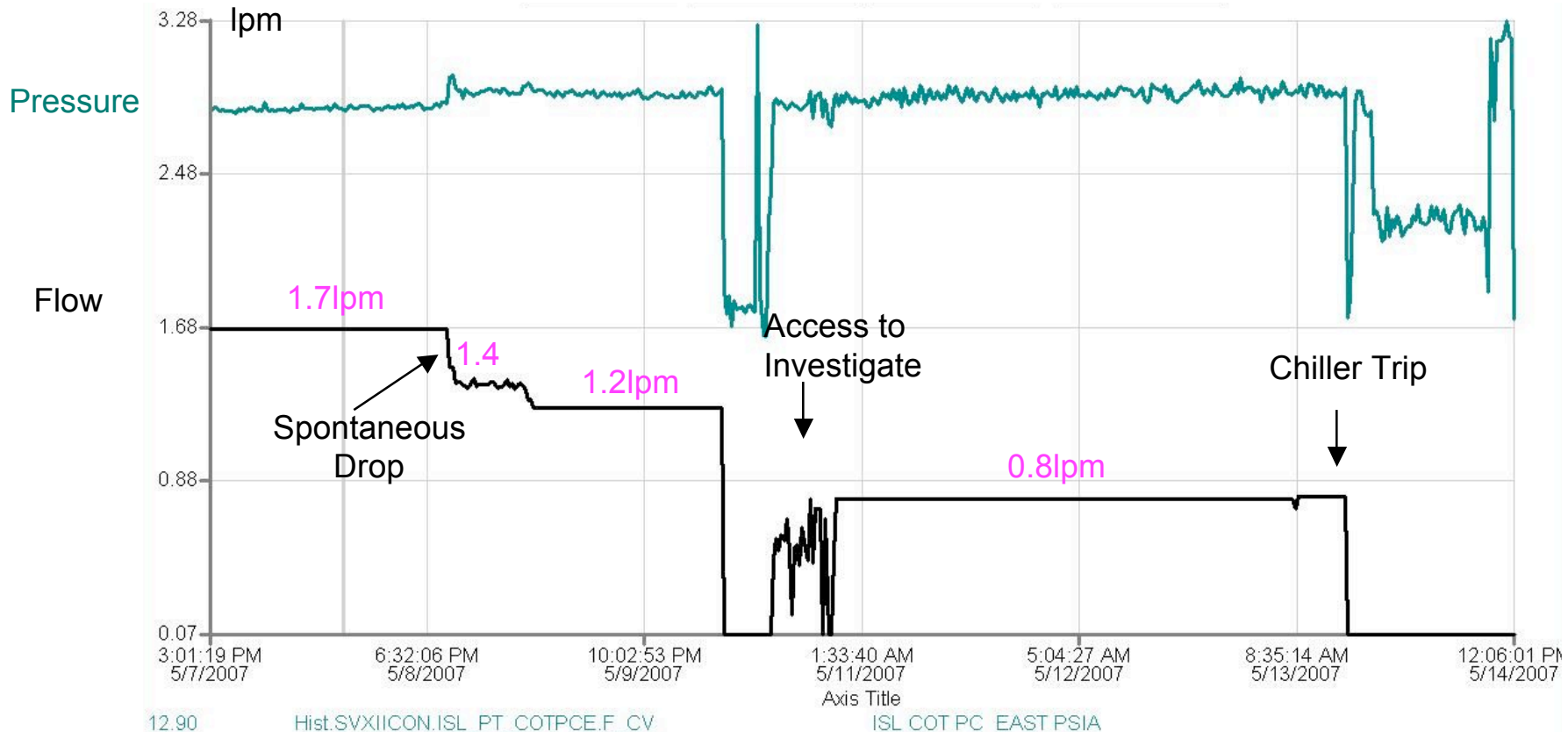
July 2, 2007

Overview

- Leak in cooling for Intermediate Silicon Layers (ISL) and Layer 00 Port Cards
  - Leak isolated to aluminum manifold on detector
  - Operating all SVX and west half of L00, ISL
- Taskforce looking at Cause, Repair method, Vulnerability and mitigation
  - Likely cause: corrosion by acidic coolant
  - Repair method developed
  - Evaluating vulnerabilities and mitigation
- Planning for 1 day access to repair next week
- Planning for the August shutdown

ISL Cooling Leak

- May 8-13 flow in East ISL/L00 portcard circuit dropped from 1.7 lpm (nominal) to 0.0 lpm:



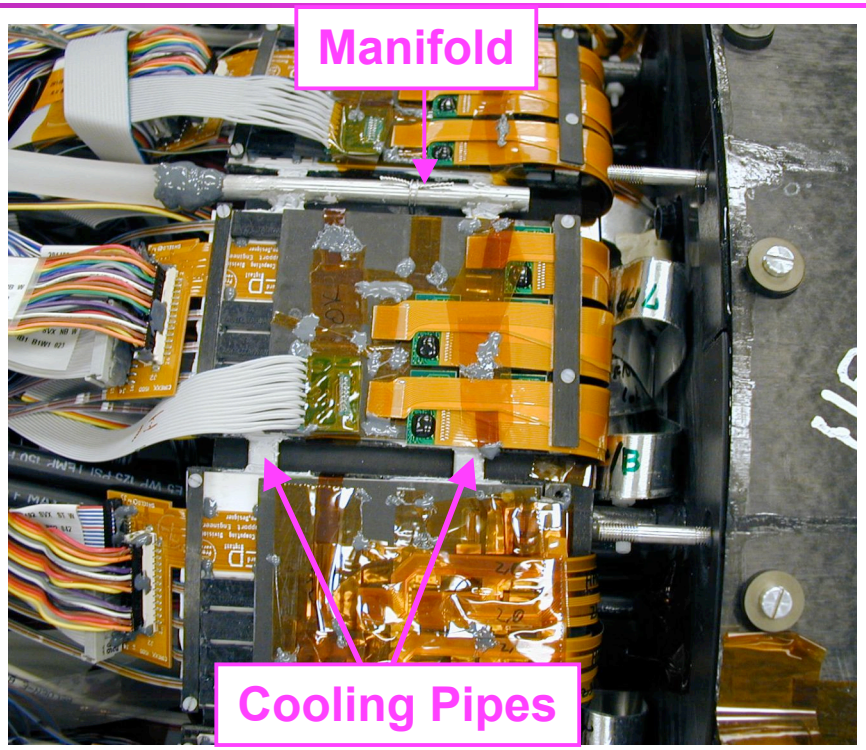
Since the Leak

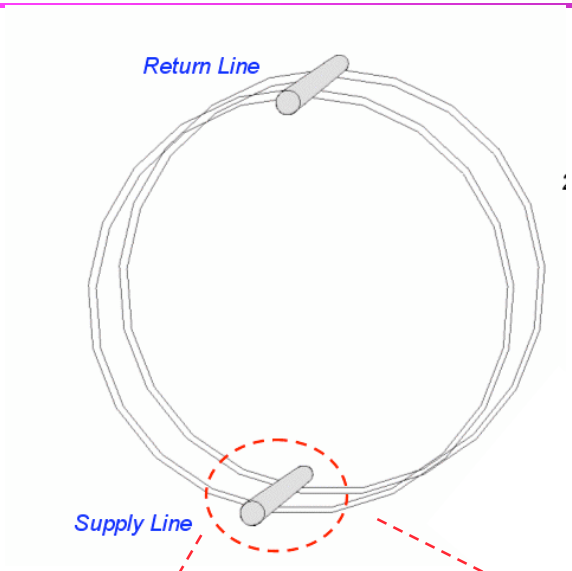
- May 16: Bore Access Found leak in portcard ring
  - SVX operating on next store, lost 2 1/2 stores
- May 24: First weekly ISL Task force Meeting
- May 26: Update cooling interlocks and re-establish operation of west half of L00/ISL
- June 4: Flow dry N2 through east portcard cooling line
- June 6: Restart flow of coolant through east ISL ladder cooling lines

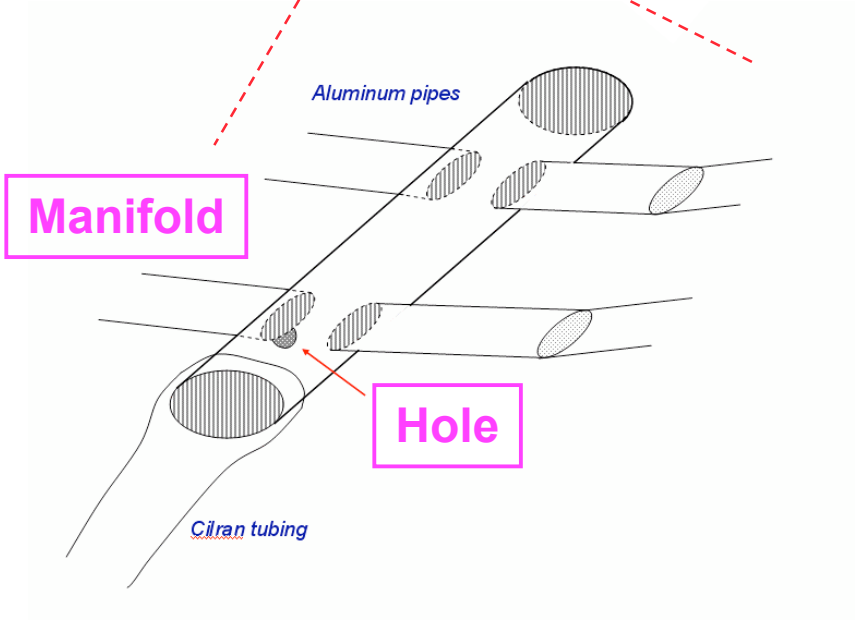
ISL Task Force: Lines of Attack

- Understand probable cause of leak
  - Goals:
    - Understand impact on method of repair
    - Prevent future problem
  - History of cooling system and coolant
  - Analysis of coolant and corrosion
    - Working with experts from industry and other labs (Argonne, CERN)
- Explore vulnerabilities in whole of system
  - Inventory of materials in system
  - Research on Al alloys and corrosion properties
- Develop repair method
  - Acquire tools - borescopes, catheters
  - Mockup of repair
- Prevention of future problems
  - Exploring surface treatments of cooling lines
  - New instrumentation for system and procedures for monitoring

ILS/L00 PortCard Cooling



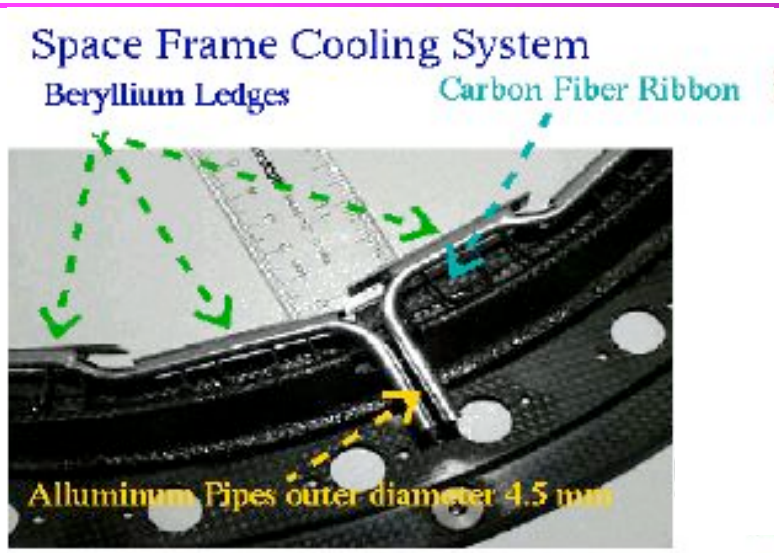




- Manifold - AL 6061-T6, 30mil wall
- Cooling Rings - AL 5052, 20mil wall
- Welded
- Inner surface area: 0.12m^2

ISL Ladder Cooling

- Aluminum tubes (AL 1100)
  - ID 3.8mm or 4.0mm
  - Wall: 10mils
  - Total tubing: 50m
  - Inner surface area: 0.6m^2
- Combined in sets of 4 or 5 via small manifolds
- Joints at manifolds and 90^o bends use epoxy
- No welds



coolant flowing in aluminum tubes attached to beryllium ledges mounted on space frame

Cause of Leak

- Erosion:
  - Unlikely: FEA of flow shows no turbulent flow
- Corrosion starting on microcracks in ovalized tubing:
  - No evidence in radio-micrographs or dye penetrant test
- Microbiologically Induced Corrosion (MIC)
  - Cause of MI cooling leak during commissioning
  - Tested coolant samples (March and June 2007) for MIC microbes
  - Consultant on MIC found no evidence of live or dead microbes in coolant
- Corrosion by acidic (conductive) coolant most probable
  - What made coolant acidic?
  - What are implications on other parts of the system?

ISL Coolant History

- Aug 2005: 100% water to 90/10 Water/Ethylene Glycol
- Mar 2006: Warm from 6C to 15C for shutdown work
  - Conductivity rises: 2μSi/cm to >16μSi/cm (Full scale)
- May 2006: Conductivity remains high after cooling down
- Aug 2006: Conductivity 1200μSi/cm
- Mar 2007: Conductivity 3000μSi/cm, pH~2
- Apr 2007: Drain and refill system
  - Conductivity 700 μSi/cm, pH~2.8
- May 2007: Intensive de-ionization
  - Conductivity <10μSi/cm, pH~4.5
  - Leak develops

Source of Acidity

- Test at Argonne analytical chemistry lab using Ion Chromatography
  - Determine what anions are present
  - Preliminary result: prominent peaks in region expected for Formic and Acetic acid, don't see inorganic acids
  - Tests of references in progress
- Likely due to breakdown of ethylene glycol
  - Rate Increases with temperature
  - Can result from biological activity which is more likely at low concentrations of glycol

Looking for Aluminum

Performed Tests of coolant for metals

- Aug 2006 - nothing significant seen at few ppb level
- March 2007 - test was not sensitive enough (~1ppm)
- June 2007 - reanalyze March coolant and analyze current with sensitivity of few ppb
  - March sample: Al ~1mg/l of coolant or ~0.7g of Al total
  - June sample: Al ~0.07mg/l or ~0.05g of Al - consistent with dilution from drain and refill in April
  - Many other materials seen in March sample (Calcium, Iron, Chromium…) but not in June sample, likely from storing in steel barrel for 2 months (had tear in liner)
- Still evaluating full implications

Implication of Tests

- Dissolved aluminum: ~0.7g
  - Pitting in portcard manifolds ~6mg (4 pits observed on east, assume 4 more on west)
  - Uniform loss of 0.1mils from Al cooling lines would yield about 1g (minimum wall thickness 10mils)
  - Conclusion: Problem extends beyond observed pitting
- Some aluminum may have deposited on surfaces
  - May not count for all of the Aluminum removed form surfaces
- We have done visual inspection of few percent of the Aluminum surface area.

Vulnerability

- Ladder cooling construction more corrosion resistant than portcard cooling
  - Welds are corrosion weak point (all pits observed in or next to welds)
  - AL1100 (ladders) more corrosion resistant than 5052 and 6061
  - Ladder tubes have thinner walls
- Galvanic action in general not very likely
  - Significant distance of insulating tubing between Al and SS
- Rest of system is SS and much thicker walls
- Need visual inspection of ladder cooling lines and west portcard cooling
  - Summer shutdown

Repair Technique

- Leak will be repaired with epoxy
- Test: deposit epoxy over hole in Al with catheter
  - Wets and fills 30, 40mil holes when applied from above or below
  - Good bonding on surface contaminated with coolant
  - Cures at temperature of tube ~15C
- Testing real mockup
  - Down 1m of tubing using catheter and borescope
  - Tests filling holes in mockup of manifold today
- High confidence that we will not be burying a lurking problem
  - No MIC in action on surface

Plans for Access to Repair

- Preparing for repair before the shutdown
  - Target middle of next week (about July 11)
  - Duration 2-3 shifts
- Goals for access
  - Confirm leak location using boresecope and catheter
  - Repair with epoxy
  - More information to use in preparation for shutdown
    - Get better images of damage in portcard manifolds using new borescopes/video equipment
- Procedure in preparation
  - Risk analysis in progress
- Make formal request by July 5

Work During Shutdown

- Examination of west portcard cooling and ladder cooling lines
  - Repair of any damage seen in portcard manifolds
  - If damage to ladder cooling lines may need to develop repair technique
- Likely drain and refill coolant to remove residual glycol
- Add instrumentation and larger de-ionizer
- Possible mitigation or prevention through coating of lines

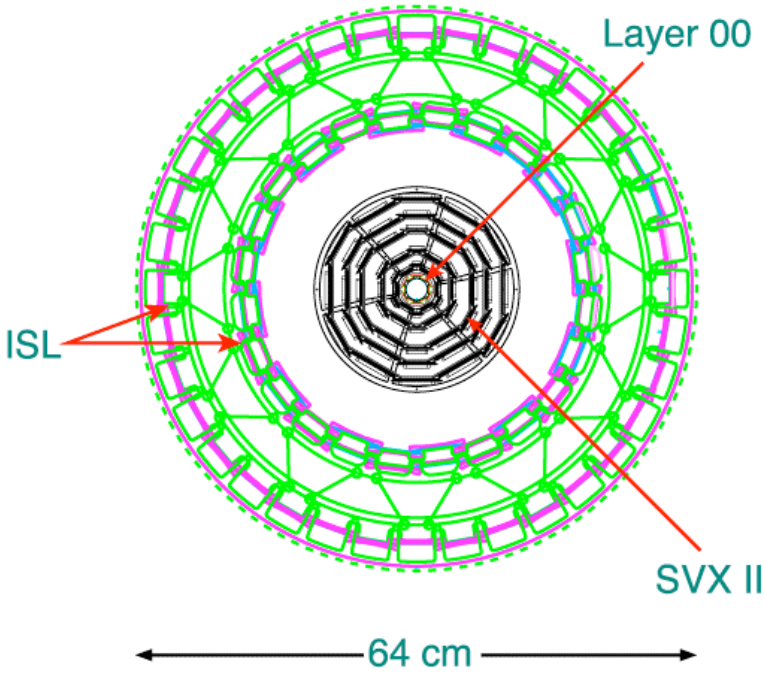
Continuing Tasks

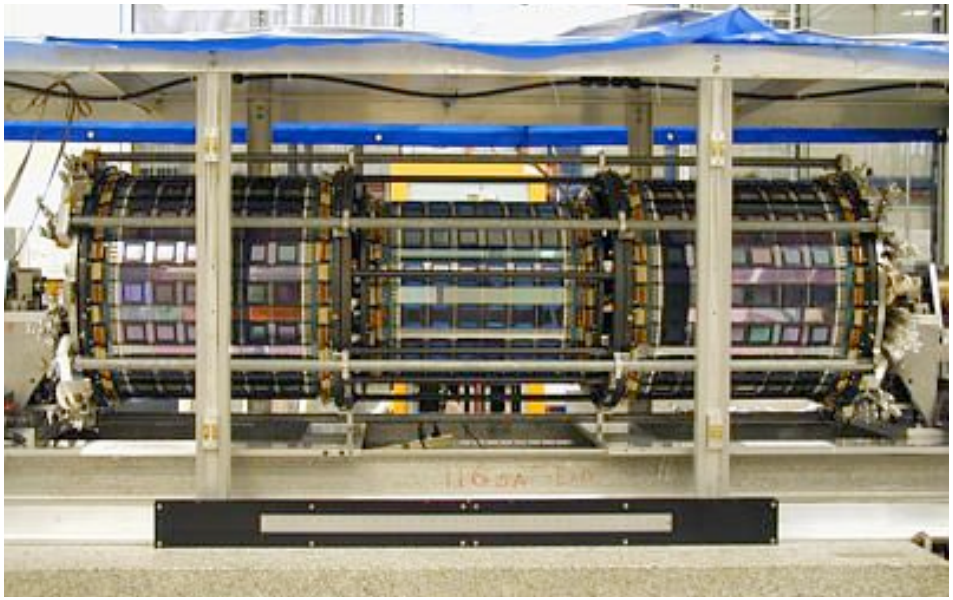
- Understanding source of problem
  - Corrosion tests being developed with samples of Al pieces
  - Research and tests of Glycol degradation
  - Consultation with corrosion experts
- Implications
  - What happens to remaining glycol (0.25%) when we warm up during shutdown?
  - Could SVX coolant degrade (30% glycol, colder)?
  - Will lurking damage result in future leaks?
- Mitigation actions
  - New instrumentation and procedures
  - Possible changes to coolant composition (eg passivation additives)

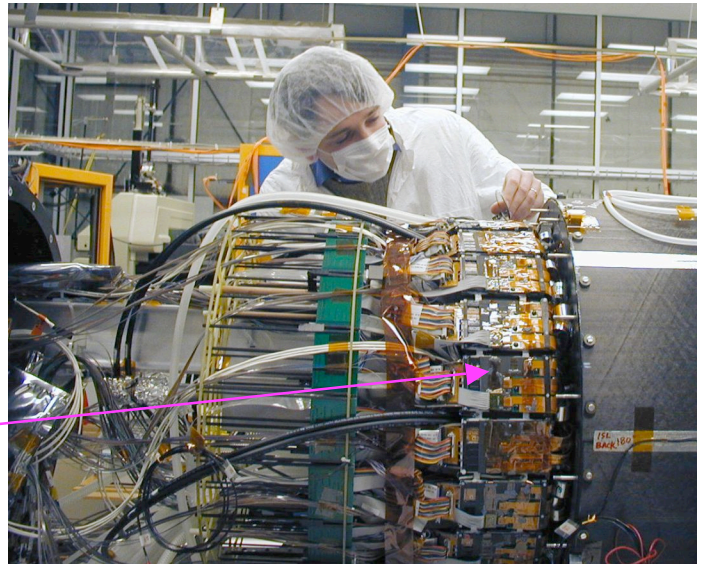
Conclusions

- Significant Progress on understanding source of problem
  - Most certainly corrosion
  - Investigations will continue for some time yet
  - Know enough to execute repair
- Repair technique well understood
- Almost ready to execute repair - next week?
- Preparing for shutdown investigation and possible repair
- Still many avenues to follow in investigation

CDF Silicon Detectors







ISL/L00 Portcards

History of Cooling System